FAA-E-2014a
February 3, 1970
SUPERSEDING
FAA-E-2014, 8/5/63

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION SPECIFICATION

TONE/SCAN CONTROL SYSTEM

INTRODUCTION: This specification consists of six parts as listed below:

Part I ---------- General Requirements

Part II ---------- Tone Equipment

Part III ---------- Scan Equipment

Part IV ---------- Terminal Power Supply

Part V ---------- Line Coupling Panel

Part VI ---------- Bias Test Set

PART I

GENERAL REQUIREMENTS

1-1. SCOPE

1-1.1 Scope.- The equipment described in this specification is a solid-state, combined Tone/Scan Control System for two-way control and monitoring of remote radio facilities over a 300 to 3000 Hz telephone circuit.

1-2. APPLICABLE DOCUMENTS

1-2.1 FAA specifications.- The following FAA specifications, of the issues specified in the invitation for bids, or request for proposals, form a part of this specification:

FAA-D-638	Instruction Books, Electronic Equipment
FAA-G-2100/1	Electronic Equipment, General Requirements Part 1, Basic Requirements for All Equipments
FAA-G-2100/3	Part 3, Requirements for Equipments Employing Semiconductor Devices
FAA-G-2100/4	Part 4, Requirements for Equipments Employing Printed Wiring Techniques
FAA-G-2100/5	Part 5, Requirements for Equipments Employing Microelectronic Devices
FAA-G-2300	Panel and Vertical Chassis, Rack

(Copies of this specification, and of other applicable FAA specifications and drawings, may be obtained from the Federal Aviation Administration, Washington, D. C. 20590, Attention: Contracting Officer. Requests should fully identify material desired, i.e., specification numbers, dates, amendment numbers, complete drawing numbers; also the request should identify the invitation for bid, request for proposal, or the contract involved or other use to be made of the requested material.)

1-3. REQUIREMENTS

1-3.1 Equipment to be furnished by the contractor.- Each equipment furnished by the contractor shall be complete in accordance with all specification requirements. Instruction books shall be furnished in accordance with FAA-D-638, in quantities specified in the contract schedule.

1-3.1.1 Major units of equipment.- The equipment to be supplied consists of two terminals as listed in subsections 1-3.1.1.1 and 1-3.1.1.2. Figure 2 is a block diagram of a system. The interconnection facilities between terminals will be two-wire telephone circuit and will be furnished by the Government. Strapping shall be provided so the system can be used with a four-wire telephone circuit.

1-3.1.1.1 Control terminal.- The control terminal shall contain the following equipment.

1.	Line Coupling Panel	1 each
2.	Bias Test Set	1 each
3.	Scan Transmitter	1 each
4.	Tone Terminal consisting of:	
	a. Mounting Cabinet (cabinet sets)	1 each
	b. AM Tone Senders (on each frequency shown on Fig. 2)	10 each
	c. AM Tone Receiver (on each frequency shown on Fig. 2)	8 each
	d. FS Sender (on each frequency shown on Fig. 2)	2 each
	e. Test Adapters	1 each
	f. Spare FS Senders (one each frequency)	1 each
5.	Terminal Power Supply	1 each
6.	Wiring Harness	1 each

1-3.1.1.2 Remote terminal.- The remote terminal shall contain the following equipment:

1.	Line Coupling Panel	1 each
2.	Bias Test Set	1 each
3.	Scan Receiver	1 each
4.	Tone Terminal consisting of:	
	a. Mounting cabinet (cabinet sets)	1 each
	b. AM Tone Senders (one each frequency shown on Fig. 2)	8 each

c.	AM Tone Receivers (one each frequency shown on Fig. 2)	10 each
d.	FS Receivers (one each frequency shown on Fig. 2)	2 each
e.	Test Adapters	1 each
f.	Spare FS Receivers (one each frequency)	2 each
5.	Terminal Power Supply	1 each
6.	Wiring Harness	1 each

1-3.1.2 Functional description of the Tone/Scan equipment.- The AM and FS tone portion of this equipment provides a means of transmitting dialing pulses and similar low-speed binary data for controlling remote relays of external equipment. The two types of senders specified are the on-off AM sender and the frequency shift sender. The frequency of each sender will be specified (Fig. 2) and will be in the range of 300 to 2700 Hz with 120 Hz spacing between frequencies. The frequency shift sender shall consist of an oscillator, the frequency shift of which is controlled by a keying network. Both the AM and FS senders have companion receivers. The AM receiver produces a relay contact closure in response to a tone from its associated sender.

The scanner equipment consists of an Electronic Monitoring System which continuously monitors the condition, either on or off, of 12 to 16 control functions, and causes responsive operations at the remote location. The two basic sub-units of the scanner are the transmitter and the receiver.

The scanner transmitter, which is used at the control site, consists of 12 functions with the capability of expansion by the addition of the proper modules to 16 functions. Input to the scanner consists of open or closed external dry contacts, the conditions of which are coded and converted in the scanner transmitter to digital information, which is transmitted on line by keying the 1620 Hz FS tone transmitter with a time multiplexed (serial) pulse train. At least once during each scan, the scanner transmitter generates one or more pulses which are unique and serve to assure that the scanner receiver at the remote site is in synchronism with the scanner transmitter.

The scanner receiver receives the signal through its FS tone receiver and sequentially inspects each pulse of the incoming serial signal to determine whether the function which it represents was on or off at the moment of interrogation. The scanner receiver then operates its output circuits (relays) such that they conform to the condition of the received time division multiplexed signal.

The above functional description is intended to show the end result required of the Tone/Scan system equipment and is not intended to define the method by which it is accomplished.

1-3.1.3 Instruction books.- One instruction book shall cover all items ordered on the contract schedule.

1-3.1.4 Schematic diagrams.- In addition to the diagrams contained in the instruction books, the following drawings shall be furnished individually encased in transparent plastic. Encasing shall be by a lamination process. Drawing size shall not be less than those in the instruction book. One set shall be furnished with each terminal as follows:

1. Cabling Diagram, showing inter-unit connections
2. Scanner Unit Schematic
3. AM Tone Sender Unit Schematic
4. FS Tone Sender Unit Schematic
5. AM Tone Receiver Unit Schematic
6. FS Tone Receiver Unit Schematic
7. Test Set Schematic
8. Power Supply Schematic

1-3.1.5 Holder.- An appropriate holder shall be provided for each terminal to store the above diagrams. The holder shall be designed for wall mounting.

1-3.2 Definitions

1-3.2.1 Service conditions.- The ambient conditions shall be those of Environment I (1-3.2.23, FAA-G-2100/1).

1-3.2.2 Power source.- The equipment shall operate from a single-phase, two-wire AC line power source. The design-center voltage (1-3.2.21, FAA-G-2100/1) shall be 120 V AC.

1-3.2.3 Noise.- For the purpose of this specification, noise shall be defined as any voltage--other than that of the signal--including spurious oscillations, receiver noise, power frequency pick-up, combination of power and signal frequencies and their harmonics, cross modulation products produced by any combination of the preceding.

1-3.2.4 Compensation range.- The term "compensation range" is defined as the range in dB of undistorted signal input levels to a tone receiver that introduces no more than 10% bias in the output signal, for any fixed setting of the input gain control in the range specified in paragraph 2-3.4.1.

1-3.2.5 Keying.- Keying as used herein means the closing and opening of the input controls of the tone senders and the scan transmitter. The term "Mark" denotes the control closed and the term "Space" denotes the control open. Where repetitive keying is required, normal signals shall be with equal mark and space intervals.

1-3.2.6 Bias.- The term "Bias" when used in connection with signals means distortion of the signal elements so they are not of normal lengths (i.e., mark and space equal). Marking bias means the mark element is longer than normal; spacing bias means the space is longer than normal. Bias in terms of percent is 100 times the ratio of the element length to that of a normal element. Examples of bias (measured under repetitive keying conditions): Zero bias is equal mark and space elements; 100 percent marking bias is continuous mark and 100 percent spacing bias is continuous space; 50 percent marking bias is with mark element 150 percent of a normal element and the space 50 percent of a normal element; 50 percent spacing bias is with space element 150 percent of a normal element and the mark element 50 percent of a normal element.

1-3.3 Construction

1-3.3.1 General.- The equipment shall be on rack panels or installed in rack mounting cabinets as specified hereinafter, for mounting in FAA cabinet racks. The desired order of mounting from top to bottom is as listed in subsections 1-3.1.1.1 and 1-3.1.1.2. The combined size of a complete set of terminal units shall not exceed 70 inches rack mounting space. Electronic circuits shall use solid-state semiconductor devices in lieu of tubes. Racks shall not be provided.

1-3.3.2 Plug-in units.- Plug-in units shall be installed in rack mounting cabinets, and shall have metal chassis with front panels which provide solid component mounting, with adequate protection for wiring and small components when inserting, or removing from, and when handling the assemblies when removed from the mounting cabinet. Each assembly shall have a suitable front handle for convenient safe handling. Controls, adjustments, test jacks, and test point jacks shall be on the front panel, accessible without having to remove the assembly from the cabinet.

1-3.3.3 Plug-in mountings.- The mountings shall be side-by-side, bookcase style, in the rack mounting cabinets, and shall include guide rails, stops, latches, mating connectors, etc., as are necessary to insure fast, easy plug-in with positive circuit connections, and fast, easy removal. Plug-in units shall plug in from the front of the rack mounting cabinet and shall be securely locked in place when plugged into the mounting positions. Rack mounting cabinets for plug-in tone units and for plug-in power supplies may be without front doors.

1-3.3.4 Printed wiring.- Printed wiring boards shall be used wherever practical.

1-3.4.1.2 Tone channel operate time.- The delay from the time a sender control is closed until the output relay on the receiver operates, and the delay from the time a sender control is opened and the output relay on the receiver releases, shall not exceed 24 milliseconds.

1-3.4.1.3 Scan-multiplex operate time.- The operate, and release, delay for each function shall not exceed two seconds.

1-3.4.2 No-bias operation.- All tone channels shall be capable of reproducing at the receiver output terminals, without added bias, the input signals to the sender when the sender is keyed with constant amplitude zero bias ON/OFF signals at 14 dot cycle. This requirement shall be met at any signal level within the input range of the receiver input control. The signal level shall be measured at line terminals of receiving terminals. (See paragraph 2-3.4.1 for input range.)

1-3.4.3 Scan-multiplex operation.- The scan equipment shall be capable of performing all function controls without error when the function input control is keyed ON/OFF at 0.25 Hz (15 cycles per minute). This requirement shall be met both on undistorted FS receiver output and with FS receiver output with 40% bias.

1-3.4.4 Fail-safe requirements.- Output relays shall be unenergized when failures which disable receivers occur in telephone circuit, prime power, or equipment components.

1-3.4.5 Sensitivity.- All tone channels shall be capable of operation on -40 dBm signals (measured at the line terminals at the receiving station) with not more than ten percent added bias.

1-3.4.6 Limiting.- With the receiver adjusted for any input level over a range of 0 dBm to -30 dBm, varying the input level at a rate of 14 dot cycles over a range of plus and minus 10 dB from the adjusted level, while keying at a rate of 14 dot cycles, shall cause no more than 10% bias in the receiver output, with no further adjustment of the receiver. The receiver shall go into space condition with its output relay remaining unenergized at all levels of attenuation of 15 dB or more from the adjusted level. The input levels shall be measured at the line terminals of the receiver terminal. The above requirements shall be met on all tone channels.

1-3.4.7 System noise.- The noise figure shall be 20 dB or better when measured in accordance with 1-4.3.2.1 and 1-4.3.3.1.

1-4. QUALITY ASSURANCE PROVISIONS

1-4.1 General.- Refer to Section 1-4 of FAA-G-2100/1.

1-4.2 Visual inspection.- All equipment shall be subject to visual inspection both during production and during acceptance, for quality of construction and compliance with requirements.

1-4.3 Tests for compliance.- The following tests shall be considered a minimum to show compliance with requirements. Since each unit of equipment depends upon one or more other units for its operation, the equipment shall be tested in terminal assemblies connected into systems. The tests are listed in Part I only. Where no line voltage is listed, power may be off. Temperature and humidity tests are required where so indicated, and shall be as specified in 1-4.12 of FAA-G-2100/1.

1-4.3.1 Design qualification tests

Isolation from ground	1-3.3.11
Line Terminations	1-3.3.14
Output Relay Terminals	2-3.4.3 2-3.3.1
Alarm Relay Terminals	3-3.3.3 4-3.3.2
Isolation line from tone drops	1-3.3.3.18

1-4.3.2 Production tests

	Line Voltage	Paragraph
Power supply outputs (contractor shall state output standards volts, mA, etc., and show compliance)	105/120/130	4-3.2
Suppression rectifier transient	120	4-3.2.1
Frequency adjust (tone senders)	120	2-3.3.2
Changing oscillator transistor	120	2-3.3.4
Frequency stability	105/120/130	2-3.3.3
Sender output control	105/120/130	2-3.3.1.3
Output level stability (senders)	105/120/130	2-3.3.1.5
No-bias operation	105/120/130	1-3.4.2

Sensitivity	105/120/130	1-3.4.5
Limiting	105/120/130	1-3.4.6
Fail-safe requirements	105/120/130	1-3.4.4
Scan operation	105/120/130	1-3.4.3
Error tolerance (scan)	105/120/130	3-3.3.2
Scan alarm (demonstrate operation)	105/120/130	3-3.3.3
Attenuation line to tone drops (two-wire and four-wire)	120	1-3.4.16.2 1-3.4.16.3
Test jacks (connection required)	120	2-3.3.6 2-3.4.4 3-3.2.1
Keying speed control (check at 8, 14, and 20 Hz)	105/120/130	6-3.2.1
Bias control (check at 0, 10, 20 and 40)	105/120/130	6-3.2.2
Bias measurement (check at 0, 10, 20, and 50 and low range 0, 5, and 10)	105/120/130	6-3.3 6-3.3.1

1-4.3.2.1 System performance production test.- System performance production tests shall be conducted with the equipment assembled into terminals and with terminals connected into a system. System noise shall be measured in AM receivers at the test point providing the output of the transistor stage preceding the output relay driver. Each AM receive channel shall be tested for system noise with its associated sender inoperative and with FS senders alternately on mark and space frequency. System noise must be at least 20 dB less than the minimum signal plus noise required to energize AM receive channel output relays. With all senders inoperative, AM receive channel output relays shall be unenergized. System noise shall be measured in FS receivers at the test point providing the output of the transistor stage preceding the frequency shift detector. Each FS receive channel shall be tested for system noise with its associated sender inoperative and with the remaining FS sender alternately on mark and space frequency. System noise must be at least 20 dB less than the signal plus noise measured with the associated FS sender operating on the mark frequency.

Performance tests shall be conducted for each of the following configurations and test conditions:

A. Four wire - with all senders in operation and each producing a -10 dBm output with a 10 dB pad connecting control and remote terminal equipment

B. Two-wire - with all senders in operation and each producing a -10 dBm output with a 10 dB pad connecting control and remote terminal equipment

C. Frequency shift and scan receivers shall be required to operate normally with a frequency displacement of ±20 Hz; i.e., with a sender frequency displacement of ±20 Hz from the specified frequency while maintaining the normal ±30 Hz frequency shift either side of the newly established center frequency.

D. With white noise injected into the system, and all AM senders inoperative, frequency shift and scan receivers shall be required to operate normally at the injected noise level which produces random operation of the AM tone receivers output relays.

NOTE: All pads shall have an input and output impedance of 600 ohms.

4.3.3 Type tests.-

	Line Voltage	Paragraph
Frequency shift (FS channels) (temperature and humidity)	105/120/130	2-3.3.1.1
FS sender output on space	120	2-3.3.1.3
Tone channel operate time (temperature and humidity)	105/120/130	2-3.5.1.2
Scan operate time (temperature and humidity)	105/120/130	1-3.5.1.3
Cross drop attenuation	120	1-3.4.16.2
Keying device (bias test set) Resistance open and close		6-3.2
Metering (volts) Show compatibility with equipment requirements and agreement with laboratory instruments		6-3.4
Harmonic output level (temperature and humidity)	105/120/130	2-3.3.1

1-4.3.3.1 System performance type tests.- System performance type tests shall be conducted with the equipment assembled into terminals and with terminals connected into a system. System noise shall be measured in AM receivers at the output of the transistor stage preceding the output relay driver. Each AM receive channel shall be tested for system noise with its associated sender inoperative and with FS senders alternately on mark and space frequency. System noise must be at least 20 dB less than the minimum signal plus noise required to energize AM receive channel output relays. With all senders inoperative, AM receive channel output relays shall be unenergized. System noise shall be measured in FS receivers at the test point providing the output of the transistor stage preceding the frequency shift detector. Each FS receive channel shall be tested for system noise with its associated sender inoperative and with the remaining FS sender alternately on mark and space frequency. System noise must be at least 20 dB less than the signal plus noise measured with the associated FS sender operating on the mark frequency.

Performance tests shall be conducted for each of the following configurations and test conditions:

A. Four-wire - all senders in operation and each producing a -10 dBm output with a 10 dB pad connecting the control and remote terminal equipment

B. Two-wire - all senders in operation and each producing a +5 dBm output with a 5 dB pad connecting the control and remote terminal equipment

C. Two-wire - all senders in operation and each producing a +5 dBm output with a 35 dB pad connecting the control and remote terminal equipment

D. Two-wire - with all senders in operation and each producing -10 dBm output with a 10 dB pad connecting the control and remote terminal equipment

E. Two-wire - with all senders in operation and each producing a -20 dBm output with a 10 dB pad connecting control and remote terminal equipment

F. The FAA representative will select one of the preceding tests (A, B, C, D, or E) for testing system performance under temperature and humidity conditions.

NOTE: All pads shall have an input and output impedance of 600 ohms.

1-5. PREPARATION FOR DELIVERY

1-5.1 General.- See FAA-G-2100/1.

1-5.2 Packaging.- Packaging shall be for reshipment by terminals.

1-6. NOTES

1-6.1 Notes. None

PART II

TONE EQUIPMENT

2-1. SCOPE

2-1.1 Scope.- This part of the specification describes the tone equipment which provides the means of transmitting the binary data over the telephone circuit and is supplemental to Part I.

2-2. APPLICABLE DOCUMENTS.- Same as in Part I.

2-3. REQUIREMENTS

2-3.1 General.- The tone equipment shall be designed for 120 Hz channel spacing with one 240 Hz send/receive guard space. Frequencies shall be as listed on Fig. 2 except that the FS channels shall be two-frequency, one 30 Hz above and one 30 Hz below the specified frequency, which may or may not be transmitted. The AM channels shall be Tone ON for Mark and Tone OFF for Space. The receivers shall operate their output relays (energize the relay coil) on Space. Power shall be from the terminal power supply.

2-3.2 Equipment mounting.- The senders and receivers shall be separate plug-in units for each frequency and shall be of the same outside dimensions so they will fit mechanically identical mountings. Mountings in the rack mounting cabinets shall be mechanically identical. More than one rack mounting cabinet per terminal may be used. Mounting positions in the rack mounting cabinets shall have channel frequency markings which are plainly visible with the plug-in units removed. The rack mounting cabinets may be identical for both terminals. Senders and receivers shall be so wired into their respective connectors that no damage can occur should either be inadvertently misplaced in the assembly during operation.

2-3.2.1 Test adapters.- Test adapters shall provide a minimum of six (6) feet extension to permit normal operation of the plug-in modules outside the rack cabinet for maintenance purposes.

2-3.3 Senders.- Each sender shall be complete with tone generating circuit, output filter, input (keying) control circuit, test jacks, and such other components as necessary to meet the requirements of the specifications. The frequency determining component shall be of the LC type hermetically sealed in a suitable metal case, except that a small frequency adjust capacitor may be external.

2-3.3.1 Sender outputs.- The sender outputs shall be sine wave signal frequency tones, with total harmonics not to exceed a level of 60 dB below the level of the fundamental.

2-3.3.1.1 Frequency shift FS channels.- The frequency shift of FS channels shall be 60 Hz plus or minus 3 Hz.

2-3.3.1.2 Output control.- Each sender shall have an output control capable of setting the output to any constant level within the range of 5 dBm to minus 20 dBm.

2-3.3.1.3 FS sender output on space.- The output on space shall be within one dB of the output on mark for any setting of the output control.

2-3.3.1.4 AM sender output on space.- The output level on space shall be less than minus 60 dBm for any setting of the output control.

2-3.3.1.5 Output level stability.- For any setting of the output control the output level of any sender shall not vary more than plus or minus 3 dB throughout the range of service conditions.

2-3.3.2 Frequency adjustment.- The frequency determining component shall be pre-adjusted at the factory to within 3 Hz of the specified frequency.

2-3.3.3 Frequency stability.- Throughout the range of service conditions the output frequency shall not vary more than 10 Hz from the pre-adjusted frequency. The frequency shall not vary more than 3 Hz when the output control is varied throughout the range of its control.

2-3.3.4 Effect of changing oscillator transistor.- After replacement of the oscillator transistor with one of the same type selected at random, the output frequency shall be within 5 Hz of the pre-adjusted frequency.

2-3.3.5 Input control.- The input (keying) control shall meet the requirements in paragraph 1-3.3.13 except that the FS sender associated with the scan transmitter shall have an input compatible with the scan transmitter output.

2-3.3.6 Test jacks.- Each sender shall have an input jack and an output jack. The input jack shall lift the sender input from its external control and connect it to the plug. The output jack shall lift the sender output from the system connection and connect it to the plug. Switching action shall be in such manner that the connection to the system is broken before the connection to the plug is completed.

2-3.3.7 Test point jacks.- Test point jacks shall be included to provide connection to the input of the filter and to other points to which connection is necessary when checking and adjusting the sender.

2-3.4 Receivers.- Each tone receiver shall have an input filter, an amplifier-discriminator-rectifier (FS unit) or an amplifier-rectifier (AM unit), an output relay and such other parts as are necessary to meet the requirements of the specification.

2-3.4.1 Input control.- Each receiver shall have an input control capable of setting the receiver to the center of its compensation range for any signal within the range of 0 to -30 dBm.

2-3.4.2 Bias control.- Each receiver shall have a control capable of varying the output bias from 10% marking to 10% spacing with the receiver previously adjusted to the center of its compensation range and operating on constant level, zero bias input signals at 14 dot cycles.

2-3.4.3 Output relays.- Each receiver, except the one associated with the scan receiver, shall have a plug-in output relay which shall be a reed or mercury-wetted contact type with one set of transfer contacts. The output of the FS receiver associated with the scan receiver shall be compatible with the scan receiver input. Relay contacts shall have separate external terminals which are isolated from ground.

2-3.4.4 Test jacks.- Each receiver shall have both an input jack and an output jack. The input jack shall be connected to lift the receiver input from the system connection and connect to the plug in such manner that the connection to the system is broken before the connection to the plug is completed. The output jack shall lift the connection to the make contacts of the output relay from output terminals.

2-3.4.5 Test point jacks.- Test point jacks shall be included to provide connection to the output of the filter and to such other points in the receiver as may be necessary when testing and adjusting the receiver.

PART III

SCAN EQUIPMENT

3-1. SCOPE

3-1.1 Scope.- This part of the specification deals with the equipment which multiplexes one FS tone channel for multiple control functions and is supplemental to Part I.

3-2. APPLICABLE DOCUMENTS.- Same as in Part I.

3-3. REQUIREMENTS

3.3.1 General.- The word "SCAN" as used herein is a general designation for the equipment units and assemblies which accomplish time division multiplexing of one FS channel to 12 control functions, expansible to at least 16.

3-3.2 Scan transmitter.- The scan transmitter shall contain the necessary circuits to monitor continuously the ON-OFF conditions set up by the associated control switches at the control station; convert these conditions into a time division multiplexed code with "sync" elements for receiver; and key the FS sender so the multiplexed code is sent continuously to the scan receiver. Various segments of the transmitter may be plug-in units, but all units, except the power supply, shall be in one assembly in one rack mounting cabinet. The operating power shall be obtained from the terminal power supply.

3-3.2.1 Test jacks.- The transmitter shall have a test jack for each input connected to lift the input from the external connection when the plug is inserted.

3-3.3 Scan receiver.- The scan receiver shall contain the necessary circuits to monitor continuously the time division multiplexed code repeated to it by the FS receiver and convert this code into ON-OFF conditions in its output relays in strict conformance with the ON-OFF conditions set up in the controls for the scan transmitter at the control station. Various segments of the scan receiver may be plug-in units, but all units, except the power supply and except output relays which may be on a separate panel, shall be an assembly in one rack mounting cabinet. The operating power shall be obtained from the terminal power supply.

3-3.3.1 Receiver output relays.- The receiver shall have a plug-in output relay for each function, which shall be a reed or mercury-wetted contact type with one set of transfer contacts. The relay contacts shall be connected to separate external terminals which are isolated from ground.

3-3.3.1.1 Output relay operation.- The output relays shall be unenergized for an OFF condition at the control station.

3-3.3.2 Error tolerance.- The receiver shall have error tolerance features which prevent the loss of conformance of the output circuits with the transmitter control switches, due to garbles of random "bits" in the scan signal by transient line disturbances. When successive garbles of signal bits cause loss of conformance with the transmitter input controls, the receiver alarm shall operate.

3-3.3.3 Alarm.- The receiver alarm shall include a relay and a red lamp. The relay shall be energized and the lamp shall be dark (out) during normal operation, but during conditions of alarm, the relay shall be unenergized and the lamp shall be lit (on). The relay shall have one transfer contact assembly terminated to ungrounded external terminals. The lamp shall be telephone slidebase, in a holder with red torpedo or stovepipe translucent lens, mounted on the front of the assembly so it is visible from any angle in front of the equipment.

3-3.4 Test point jacks.- Test point jacks shall be provided, both on transmitter and on receiver, for all points to which connection is necessary for testing and adjusting the units.

3-3.5 Test adapters.- If plug-in boards are used, a test adapter shall be provided to extend the connections so the boards can be tested while in operation. The cabinets shall contain a special mounting space for storing the test adapter when not in use.

3-3.6 Scan signal.- This signal shall be transmitted over an FS channel. The number of signal bits per scan cycle (also applicable after expansion to sixteen functions) shall not exceed 75 per second.

3-3.7 Control function.- Control functions in the transmitter, and likewise in the receiver, shall be set up with plug-in units (or plug-in boards) plus additional units (or boards) as needed for timing. The function units in the transmitter, including those units required for expansion of functions, shall be identical and interchangeable. Likewise, the function units in the receiver, including those units required for expansion of functions, shall be identical and interchangeable.

3-3.8 Expansion of functions.- The equipment shall be supplied for 12-function operation but mounting places, wiring, etc., shall be included in the assemblies so the number of functions can be expanded to at least sixteen by the addition of plug-in units, with no wiring change other than changing a minimum number of jumpers specifically included in the equipment for that purpose.

PART IV

TERMINAL POWER SUPPLY

4-1. SCOPE

4-1.1 Scope.- This part of the specification describes the Terminal Power Supply and is supplemental to Part I.

4-2. APPLICABLE DOCUMENTS.- Same as in Part I.

4-3. REQUIREMENTS

4-3.1 General.- The terminal Power Supply shall be an assembly of two power units in a rack mounting cabinet. The power units shall be plug-in units with the outputs connected in parallel through a suitable isolation device.

4-3.2 Power units.- Each unit shall be a complete power supply capable of supplying all power required for a terminal (bias test set excepted) under continuous unattended operation under all service conditions. The outputs shall have adequate filtering and regulation to meet all requirements throughout the range of service conditions. All units shall be identical and interchangeable in the mounting positions.

4-3.2.1 Rectifier switching transients.- No transient or pulse type distortion shall be present in the supply outputs. All rectifier transients shall be suppressed within the power supply.

4-3.2.2 Fusing.- Separate fusing shall be provided for each power unit in such a manner that fuse failure for one power unit will not disable the other. Fuses shall be provided for both the input and output on each power unit and the input fuseholders shall be a type which indicates the defective fuse by lighting a neon lamp. The fuseholders shall be on the front panel so that the alarm lights are visible from any angle in front of the equipment. Suitable fusing and incandescent fuse failure indicators shall be provided for the power supply outputs.

4-3.3 Power supply isolation.- Each power supply unit shall have an isolation device which shall consist of silicon blocking diodes preferably having operating characteristics equal to those of the silicon rectifiers and which shall be an integral part of each power supply unit. These diodes shall be arranged in circuitry so that each power unit is isolated from the other. Should either power unit fail, this device shall provide sufficient isolation as well as 50% $\pm$ 5% load splitting to permit continued normal operation of the equipment with the remaining unit.

4-3.3.1 Operation indicating lights.- There shall be two operation indicating lights on each power unit; an incandescent lamp which shall be lit only when the unit is functioning normally and an incandescent lamp which shall be lit only when the unit has failed. The lamps shall be in holders on the front of the power units, and shall have faceted lenses visible from any angle in front of the equipment.

4-3.3.2 Test point jacks.- Test point jacks shall be provided on the front of the panel and connected so that all output voltages of the supply in service can be measured from these jacks.

PART V

LINE COUPLING PANEL

5-1. SCOPE

5-1.1 Scope.- This part of the specification describes the Line Coupling Panel and is supplementary to Part I.

5-2. APPLICABLE DOCUMENTS.- Same as in Part I.

5-3. REQUIREMENTS

5-3.1 General.- The Line Coupling Panel shall contain the line terminals, isolation/hybrid transformers, hybrid balance networks, strap terminals, etc., for strapping two-wire or four-wire service, as is necessary to couple the terminal tone equipment to the telephone circuits in the manner necessary to meet the performance requirements of the specifications. The panel shall be arranged for rack mounting and shall not be larger than size B.

5-3.2 Line terminals.- The line terminals shall be on a separate block located on the lower left rear of the panel (viewed from the rear).

5-3.3 Two-wire/four-wire strapping terminals.- These terminals shall be on a separate block. Terminals for connection of additional resistance and/or capacity to the hybrid balance networks may also be on this block.

5-3.4 Isolation/hybrid transformers.- These units shall be included as required to meet the performance requirements.

5-3.4.1 Hybrid balance.- Balance networks (if required) shall be provided, together with external terminals for connection of additional resistance and/or capacity.

5-3.5 Test jacks.- Line, bridge, and equipment jacks shall be provided for each telephone circuit.

PART VI

BIAS TEST SET

6-1. SCOPE

6-1.1 Scope.- This part of the specification describes the Bias Test Set and is supplemental to Part I.

6-2. APPLICABLE DOCUMENTS.- Same as in Part I.

6-3. REQUIREMENTS

6-3.1 General.- The test set shall contain a keying device for keying the tone senders, a device for measuring signal bias, and instrumentation for measuring voltages in equipment units. The test set shall be complete on a rack mounting panel with self-contained power supply. The meter and all switches, controls, and jacks shall be accessible from the front.

6-3.2 Keying device.- The keying device shall be capable of "square-wave" keying the system tone senders with repetitive dot cycle signals. Keying shall be by closing and opening a pair of dry contacts which give clean breaks and positive makes without chatter or bounce. The resistance across the keyer contacts on SPACE (open contacts) shall be not less than one megohm, and shall be negligible (less than 0.1 ohm) on MARK (closed contacts).

6-3.2.1 Keying speed control.- The keying device shall have a calibrated speed control capable of setting the keying speed at any constant value within the range of 8 to 23 dot Hz. The calibration shall be increments of not more than one Hz and accurate within 10 percent.

6-3.2.2 Bias control.- The keying device shall have a calibrated bias control capable of setting the keying bias to any value within the range of 100 percent marking to 100 percent spacing, with zero bias at the center of the scale. Marking bias shall increase with clockwise rotation of control, and spacing bias with counterclockwise rotation. Calibration shall be in increments of not more than 2.5 percent and accurate within 5 percent of the indicated value.

6-3.3 Bias measuring device.- The device shall be capable of direct indication of percent bias in repetitive OFF-ON (dot cycle) signals, at any constant speed within the range of 8 to 23 Hz, when connected across keyer contacts or across contacts of keyed relay. All power required for the indicating device shall be from the test set power supply.

6-3.3.1 Range switch.- A non-locking spring-return push-button selection switch shall provide two bias ranges: zero to 100 percent accurate within 5 percent, and zero to 10 percent accurate within 10 percent. The zero to 10 percent range shall be selected by operating the push button; connection for zero to 100 percent shall be made with switch in normal position.

6-3.4 Metering.- Metering shall utilize a multi-scale meter having a zero center balanced movement, and selector switch with resistance network such that bias and voltage measurements can be made with one meter. Voltage ranges shall be compatible with the requirements for checking and adjusting the system equipment.

6-3.5 Connection to system units.- Jacks (same as those listed as test jacks) shall be provided for plug-cord connection from keying device to the tone sender inputs, and from the bias measuring device to the receiver outputs. Test jacks of the tip-sleeve type only shall be provided for connection of the meter as a voltmeter to the test jacks on the other system units.

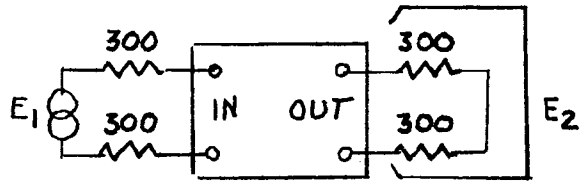
6-3.6 Connection cords.- Each test set shall be supplied with a connection cord terminated at each end with plugs compatible with the jacks, and long enough to reach conveniently from the test set to any of the tone units. The cords shall be self-retracting coil cord type.

6-3.6.1 Test leads.- Each test set shall be supplied with one set of test leads terminated at each end with pin prods which fit the test point jacks, and long enough to reach from the test set to the test jacks on all of the terminal equipment units. The leads shall be color coded red and black.

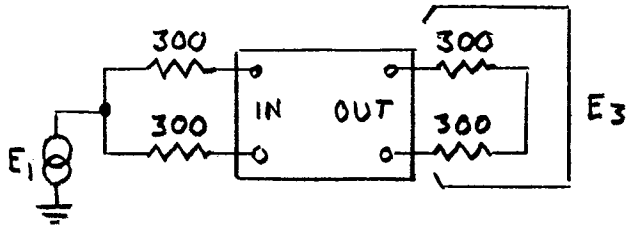
6-3.7 Power supply.- The self-contained power supply shall furnish all power required for the operation of the test set and shall have a separate power cord.

* * * * *

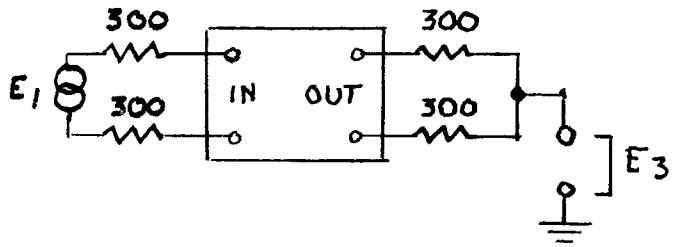
See Pages 25 and 26 for Figures 1 and 2.



ATTENUATION



LONGITUDINAL BALANCE



BASIC FORMULAS

$$\text{ATTENUATION} = 20 \log \frac{E_1}{2E_2}$$

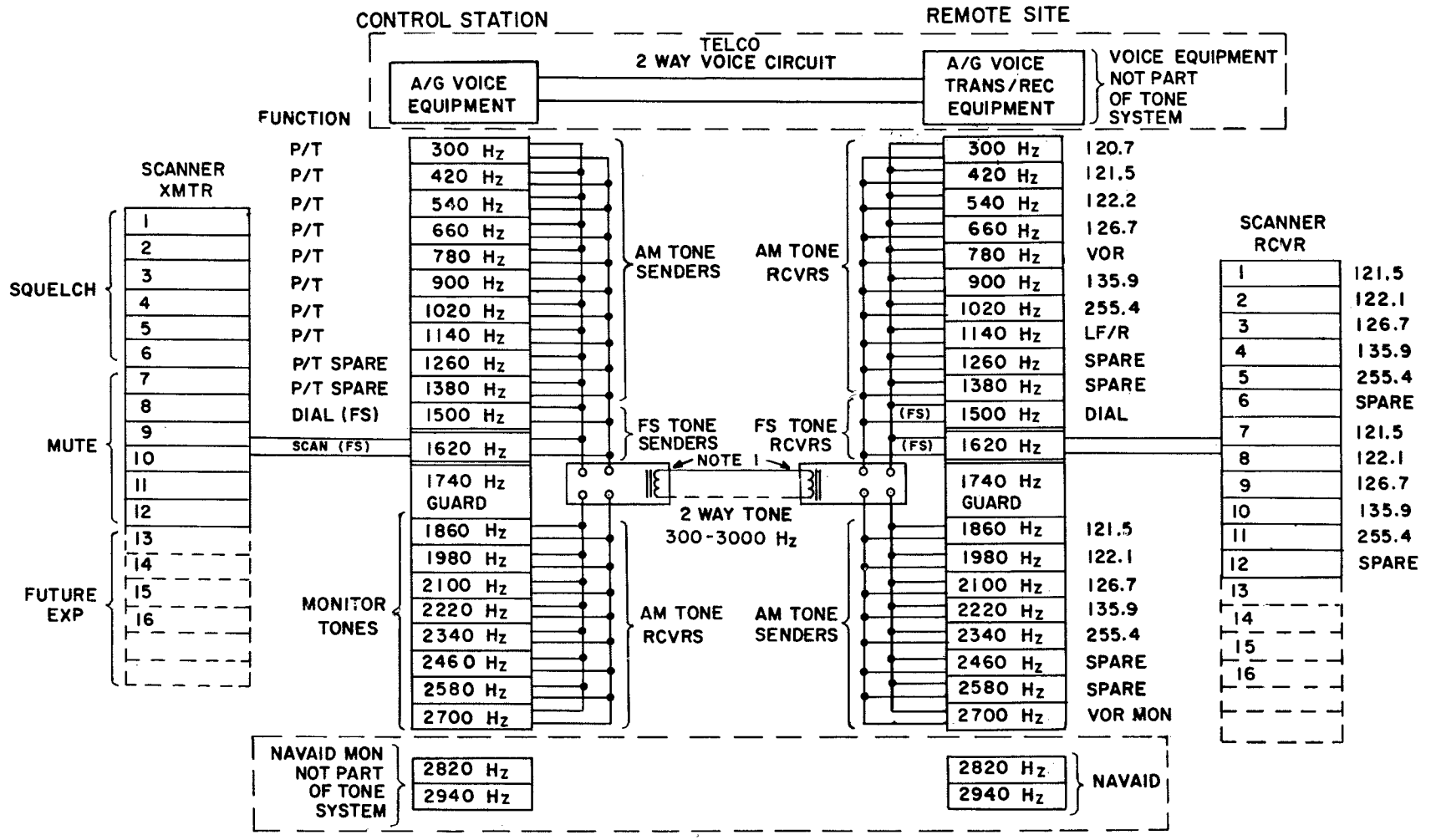
$$\text{LONGITUDINAL BALANCE} = 20 \log \frac{E_1}{2E_3}$$

SPECIAL CASE; WHEN ATTENUATION IS NEGLIGIBLE LONGITUDINAL

$$\text{BALANCE} = 20 \log \frac{E_2}{E_3}$$

ATTENUATION AND LONGITUDINAL BALANCE METHOD OF MEASUREMENT

FIGURE 1



NOTE:

1. LINE COUPLING PANELS.

VOICE FREQUENCY TONE AND SCANNER SYSTEM

FIG. 2

FILE B-15051

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